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A Review of Literature Relevant to Unaided Tactical Decision Making

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As part of a larger research effort entitled "Mission-Based Simulation and Training Requirements," a limited search was conducted for literature relevant to unaided tactical decision making. The specific purpose was to acquire information that could be used to develop a methodology for training military leaders to make tactical decisions. Particular emphasis was placed upon the training of U.S. Army Armor tank platoon leaders as tactical decision makers.

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Item 20 (Continued)

Two approaches to the study of decision making were discussed: (1) the prescriptive (economic or rational) model which holds that opinions should be expressed in terms of subjective probabilities and revised by application of Bayes' Theorem as new information is received; and (2) the descriptive approach which attempts to delineate the decision maker's behavior as accurately as possible.

On the whole, the literature review demonstrated that people do not use a prescriptive model, especially in complex or multiattribute situations. Several studies of tactical decision training for small military units were revised, as were a number of commercial programs available for decision making training. Procedures used by the Air Force and NASA to train air/space craft personnel to respond to various emergency situations were described.

Two problems encountered by developers of decision making training programs were discussed: (1) providing for consequences of decisions and (2) evaluating decision making performance.

It was concluded that training a decision maker to apply the prescriptive model without the assistance of aids (such as a computer) is not likely to prove effective. Three approaches to training in decision making were recommended.

FOREWORD

AirLand Battle doctrine emphasizes the important role of subordinate leaders during combat. The vulnerability of command and control facilities and the highly mobile nature of future combat suggest that platoon leaders and company commanders will operate with greater independence in the future than in the past. Leaders will be required to make rapid decisions intended to counter enemy actions and to respond to rapidly changing battlefield conditions.

To help train leaders to exercise command and control in this type of battlefield environment, the US Army Research Institute for the Behavioral and Social Sciences (ARI) has developed a methodology for preparing tactical leadership exercises. An important component of these exercises is training in making tactical decisions. One phase of the development of this methodology was a review of the professional literature on decision making. The purpose of the review was to identify principles of decision making or decision making strategies that could guide the development of the methodology or that could be incorporated into the exercises. This report contains a summary of this literature review which may be useful in developing training programs for tactical decision making.

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A LIMITED SEARCH FOR LITERATURE RELEVANT TO UNAIDED TACTICAL DECISION MAKING

INTRODUCTION

Applications of advancements in technology during the past two decades lead to expectations that a future military conflict will reflect a greatly increased pace and intensity, as compared to the situations encountered during World War II, Korea, and Vietnam. The outcome of encounters with unfriendly forces may well depend as heavily on the intellectual skills -- especially decision making skills -- of friendly force leaders as upon the operational effectiveness of man/machine systems.

A great amount of research has been devoted to attempts to describe the cognitive processes involved in decision making. Only recently has some concerted effort been expended to develop techniques for improving decisions. Nickerson and Feehrer (1975) note, however, ". . . despite numerous references to the importance of the training of decision makers . . . the number of studies that have explicitly addressed the question of exactly what should be taught and how the teaching can best be accomplished is remarkably small" (p. 3). (Also see Hopf-Weichel, Lucaccini, Saleh, & Freedy, 1979.)

This document reports on a limited sample of the literature on decision making. The review was conducted as part of a research project supported by the Army Research Institute for the Behavioral and Social Sciences: "Mission-Based Simulation and Training Requirements" (*MDA903-80-C-0223*). It was undertaken to provide a source of information for development of leadership training exercises. In particular, its purpose was to acquire information on decision making with particular reference to its bearing on the training of military leaders for tactical decision making. Samet (1978) writes:

> If tactical decision making is the process of converting information into action, then it is clear that tactical decision making success depends primarily on *what information is chosen and how the conversion is executed.* The difference between a good tactical decision maker and a poor one lies at this point. (p. 2-5)

The need to provide decision makers with techniques for organizing, analyzing, and presenting information in ways that they will find useful to assess rapidly changing situations and decide upon courses of action is a cause for concern across the military services. Much discussion of the means for improving performance of decision makers has appeared in the psychological literature during the last decade and a half (Nickerson & Feerher, 1975; Samet, 1978; Shelley & Bryan, 1964; Vaughan & Mavor, 1972).

Nickerson and Feehrer (1975) point out that the term "decision making" has been applied to a very broad range of human activities. However, they continue:

> Probably when the term is used in industrial, governmental and military contexts, what the user has in mind is something close to what Schrenk describes as situations characterized by fairly well defined objectives, significant action alternatives, relatively high stakes, inconclusive information and limited time for decision. (p. 1)

These characteristics are especially relevant to military decision making. Yet, if the literature search had been confined to studies that had all of these characteristics, the large majority of research reports on decision making would be removed from consideration for the following reasons: (1) very few studies of decision making in laboratory settings have involved high stakes; (2) the significance of possible action alternatives to experimental subjects has not been personally relevant. That is to say the beneficial gain to the research subject is minimal and when participation in the experiment is completed, the subject incurs no consequence of the decision made. This is, in fact, because no real decision has been made. No change in the course of events of the subject's life has occurred. Yet, to preclude consideration of all the research that has lacked the prime characteristics of military decision making, as stated by Nickerson and Feehrer (1975), would preclude detailed consideration of studies that could have relevance to the developmental problem which this report addresses. During the review of literature, therefore, laboratory studies that appeared "simple and inconsequential" were included, with the goal of extrapolating the methods used in solving such decision problems if they appeared applicable to decision making of problems that are "complex and consequential" (p. 1).

Shrenk, Nickerson and Feehrer (1975) observe that there are three ways to improve the performance of the human decision maker: (1) by selection, (2) by training, and (3) by providing decision aids. The primary focus of this literature review was upon improvements of decision making through training. We have also been concerned, specifically, with any documentation that might generalize to tactical decision making by US Army Armor tank platoon leaders.

DECISION MAKING

The distinctive factor in decision making (or problem solving) is the recognition of choice. The decision maker is faced with selecting one from among two or more alternative actions. In our view decision making is characterized by the following activities:

1. Recognition of a decision requirement or that a problem exists.
2. Consideration of current information.
3. Gathering of new information.
4. Evaluation of available information.
5. Generation or recognition of alternative courses of action.

6. Selection of action deemed most promising.

7. Implementation of decision.

8. Evaluation of decision.

We do not mean to imply that a decision maker necessarily must cover all of these steps, that they must be done serially rather than reiteratively, or that they are performed explicitly at all. Further, this is admittedly an arbitrary classification. For some instances, a level of organization in greater or lesser detail may be more useful. For a tank platoon leader in a tactical situation, however, this would seem to be a manageable classification, especially under stresses of combat and serious time restriction.

Other investigators have described the task of the decision maker in broader terms or in much finer detail. These range from three phases of activity in Howard's conceptualization, to six categories under which a total of 19 skills are subsumed in the Hill and Martin model, or alternatively, to three major phases under which a total of 30 components appear in the Schrenk model (which was proposed for structuring decision making by man-machine systems). Each of these is well-described in Nickerson and Feehrer (1975).

There are two basic "camps" of workers in decision making theory.[1] The first has often been called the prescriptive, economic, or rational approach; the second, the descriptive approach. The main proponents of prescriptive models have been economists and mathematical statisticians. Psychologists and other students of human behavior introduced, and have tended to support, descriptive models.

Prescriptive models of economic man indicate how one should make decisions. Bayes' Theorem, for example, prescribes how to revise in light of new information one's estimate of the likelihood of an uncertain event occurring. Research (Slovic and Lichtenstein, 1971) has shown that, while human judgment is necessary in estimating the value and conditional probability of new information, the Bayes' model processes that information more accurately than does a human.

Unfortunately, people have difficulty in arriving at and processing the information required by the prescriptive model. In proposing a probabilistic information processing man-machine system, Edwards and Phillips (1964) observed, ". . . men, required to draw conclusions from fallible data, do it poorly enough to leave room for vast improvement" (p. 360). They go on to write, "Until rather recently statistics as an academic discipline had remarkably little to say about how to make inferences from data obtained from several qualitatively different sources. Nor did the technology of information processing and display for deterministic systems come to grips with the problem. Such inferences were left to unaided expert intuitive judgment, both in the theory of classical statistics and in the practice of military (and civilian) information processing" (p. 364).

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[1]Actually, each has been extended into several additional "sub-camps" by way of refinements in attempts to improve the way each model works.

The objective of a descriptive approach to decision making is to discover, through empirical study, how humans perform in decision making situations. The investigator often attempts to construct a model which simulates as accurately as possible the behavior of the decision maker. To the extent that this approach leads to an explanation or understanding of the behavior, it may be possible, not only to predict it, but to improve the decision maker's performance.

MAN AS DECISION MAKER

Much research, most in laboratory situations, demonstrates that people do not follow the classic economic model of decision making. Taylor (1963) noted, "Economic man is presumed to have three properties. He is: (a) completely informed, (b) infinitely sensitive, (c) rational . . . He is assumed to know all the courses of action open to him and also what the outcome of any course of action will be. That this assumption is unrealistic is clear" (p. 5).

In 1947 Simon introduced the concept of "satisficing" (discussed below) and subsequently, in 1957, proposed the "principle of bounded rationality." He found that rationality is limited by lack of knowledge and man's capabilities for processing a complex aggregation of it, some of it of dubious relevance and reliability. In a study of decision making in administrative organizations, he proposed that an adequate theory must realistically reflect the limits imposed upon rationality in decision making in organizations. (See Taylor, 1963, p. 25.)

Taylor (1963), in a discussion of satisficing, describes the purchase of an acceptable automobile among 300 alternative models available. He proposes that the individual ". . . will fail to pick the optimal one, selecting instead one less than optimal but one which met the minimum standard with which he approached the choice situation." Elsewhere satisficing has been described as finding, not the sharpest needle in the haystack, but one sharp enough (Crecine, 1980).

Miller (1951) observed that persons who encounter problems in real life situations have two uncertainties: (1) they are not sure they have all the information and (2) they are not sure there is a solution.

These difficulties are amplified by Osborn and Goodman (1966). They write that not all necessary components for a decision may be "given." When this happens, the decision maker must determine the elements that need to be sought. This implies the need for rules or principles for developing the essential array of elements. In addition, many problems do not contain an exhaustive or apparent set of alternate actions; thus, the burden is on the decision maker to specify them.

Vaughan and Mavor (1972) provided a review of empirical findings from studies of behavioral decision making. In their summarization they found:

1. Humans delay initiating an action.

2. They are conservative in their diagnosis of a situation.

3. They delay making a change in a preplanned action or in incorporating a change in the prior estimate of a situation even when new data indicate they should.

4. They do not generalize from training on complex decision tasks unless specific relationships between tasks are explained. This precludes, currently, any broad generalization of decision making principles.

5. Humans, on the whole, are not particularly inventive. They have trouble generating alternative actions and are prone to seize upon the first solution they develop.

6. When alternatives are developed, they have difficulty in developing and using more than one criterion at a time to evaluate the probable outcome if an alternative is chosen.

7. Because they tend to select the first alternative they develop, they also concentrate their attention on criteria that support this alternative or action.

8. They tend to ignore ambiguous or incomplete information, thus limiting themselves to facts in which they have high confidence.

On the other hand, Vaughn and Mavor (1972) found that the decision maker ". . . is a good judge of the probability of single items of information" and ". . . of the relative importance of those criteria he can identify" (p. 274). More recently, Samet (1978) has provided a summary of empirical findings. Eight of his nine summary points are almost identical to those of Vaughan and Mavor, above. The additional finding (discussed in Vaughan & Mavor but not included in their summary) is that humans are poor aggregators of probability and utility according to normative rules of expectation theory.

Other characteristics of decision making behavior emerged in our limited review. These are summarized below.

1. In a study of "concept attainment" or "discover the rule" reported by Bruner, Goodnow and Austin in 1956, they found that on balance the performance of their subjects was quite good. However, "Among the limitations that were noted were a tendency to persist in focussing on cues that had proved to be useful in the past even if they were not useful in the present, and an inability to make as effective use of information gained from noninstances of a category as of that gained from category exemplars." (See Nickerson & Feehrer, 1975, p. 51.)

2. In an article by Crecine (1980) on improving team performance, a summary of the characteristics of human information processing is presented. Among the key research findings, he reports that when individuals are given a problem with many dimensions they tend to focus on only a few of its relevant

dimensions. These simplifying strategies are used by experts as well as by lay people. In fact, "Experts often consider even fewer of the dimensions of a situation or problem" (p. 55).

Decisions are generally made by reference to an internal "model" or "definition of the situation" based on past information or previously constructed models. The model, when evoked in a new decision situation, ". . . is used to interpret other information, generate alternatives, and make choices" (p. 55). Experts generally have available a more elaborate definition of the situation than lay people and their choice, based on their model, is frequently more elaborate. For these reasons, however, the expert's choice is also usually more tightly constrained.

Because of human limitation in comprehending a large number of factors simultaneously, Crecine reports that large amounts of relevant information often lead to less appropriate decisions. Past research shows that people do not choose the best alternative or optimal decision but choose the first acceptable alternative; i.e., they satisfice. He reports also that people place undue reliance upon ". . . concrete, personalized information" (p. 55).

While decision makers remember the outcome of previous choice situations, they tend to remember only a few of the salient attributes of the choice that arose from the particular "internal model" or representation of the situation they used.

In general, individuals solve problems by breaking them up into a series of subproblems and then attack the subproblems one at a time (p. 56).

Crecine finds that professionals may be more dependent upon heuristics than inexperienced people. When heuristics are acquired through formal learning and rehearsal, however, they are more resistant to change. In addition, stressful situations exacerbate the tendency of individuals to rely on only a few scenarios and to use only a few pieces of information to identify the seemingly appropriate scenario, which then defines the situation and suggests the appropriate course of action (p. 56).

While Crecine seems to indicate that formally learned heuristics have basically negative implications, in the next section it will be seen that they may, in fact, be positively employed, at least in time-constrained environments.

In a discussion of team/organizational behavior, Crecine observes that over time groups develop structured information environments, i.e., they operate within an expected range of information and shared values. Routines or standard procedures become established within this framework. Crecine sees these structures as parallel to the definition of the situation at the individual level and, once created, as highly resistant to change. The organization, working within this framework, tends ". . . to convert unfamiliar information and signals to the familiar, and to convert situational definitions into those sorts of things that look like what the organization knows how to do. An extreme example is that of U.S. military organizations preparing to fight the last war, converting particular military threats into situations that the organization has dealt with before" (p. 57).

3. In a document prepared for the US Air Force, Castore (1978) has reported that at high levels of information load integrated decision making is replaced by respondent decision making -- individuals simply respond to each issue as it arises without coordinating information or coordinating decisions. He found that pilots engage in a great deal of preplanning. They anticipate problems and rehearse responses both on the ground and in flight. This allows the pilot to stay ahead of the aircraft.

Castore also reported that people delay in making decisions when there is no clear-cut objective criterion or feedback. They may engage in far more information search than is actually needed. Individuals are more likely to integrate irrelevant information into a decision when there are low levels of information involved. The resulting decision may be technically correct, given the information used, but can lead to an undesired outcome.

Finally, Castore noted that on occasion, aircrews have been known to focus (fixate) on one particular piece of information, failing to coordinate information.

An aspect of decision making that has received considerable study is conservatism in making probability estimates. Much of this work has been reviewed in Slovic and Lichtenstein (1971). The term is used to describe human revision of posterior probability estimates when confronted with new information. Typically, these revisions are in the correct direction with reference to the optimal model but are too small. Three explanations of the judgment process that leads people to this error have been advanced: (1) Misperception of the data generator or model or assumptions used by the experimenter; (2) Misaggregation, which has been found when several pieces of information are shown simultaneously or when dealing sequentially with data; and (3) Response bias, which has been found in the revision of the posterior odds that a chosen hypothesis is correct. Response bias is supported by the finding that subjects tend to be optimal when dealing within an odds range of 1:10 to 10:1 but become conservative when forced to move outside this range (DuCharme & Peterson, 1968; DuCharme, 1970). An inertia effect has also been found: as more information accumulates subjects become increasingly resistant to change.

In a study on judgmental biases, Tversky and Kahneman (1977) report that people assign greater weight to data that appear causal in nature, within their frame of reference, than to data that are diagnostic (i.e., reflect contingency relationships) -- even though the data are equally informative. They also report, ". . . base-rate data that are given a causal interpretation affect judgments, while base rates that do not fit into a causal schema are given little or no weight" (p. 1-3).

A study on reducing the potency of such judgmental biases was reported by Fischoff, Slovic, and Lichtenstein (1978). The debiasing technique they used was simply to ask subjects to perform a sensitivity analysis on their own judgments. Three kinds of information were used in their study: base rate, validity and sample size. Subjects were asked to make predictions, given alternative values of a datum, in problems based on the three kinds of information used (e.g., in one base rate problem base rates of .15 and .85 were used). They found that about two-thirds of the subjects changed their judgments for

base rate and validity information as alternative values were given. The vast majority of these changes were in the right direction but considerably smaller than they should have been. However, no such sensitivity was demonstrated with variations on sample size information. On the whole, the authors report that this technique appears to have potential usefulness as a debiasing procedure. The procedure may at least serve as a useful heuristic in improving a person's intuitive judgment by considering a range of values about a presented datum. (They found no generalization of the debiasing technique when analogous problems were presented, however.)

A few somewhat incidental observations are included below.

Kanarick, Huntington, and Peterson (1969) point out that accuracy of a decision may increase with information acquired over time but that the tactical value of that decision may decrease concomitantly. They conclude that "subjects cannot adequately assess the utility of sources in relation to their cost" (p. 385). An optimal stopping procedure is needed.

While it is highly unlikely that restrictive selection procedures would be considered for the improvement of military decision making, Kogan and Wallach (1964) report these findings: persons who are high in defensiveness and in the tendency to react to stress with anxiety may be especially susceptible to responding irrationally, i.e., to strike out blindly or to become immobilized. They also found:

> Among the individuals high in both test anxiety and defensiveness, the failure of a risky strategy leads to a heightened affirmation of that strategy. In contrast, for the low test anxious -- low defensive persons, just the reverse pattern obtains -- failure of a risky strategy leads to an increase in desired shifts toward conservatism. (p. 212)

TRAINING TO IMPROVE DECISION MAKING BEHAVIORS

Three studies of tactical decision training in small units were found. The first reports on training at the tank platoon level (Baker, Cook, Warnick, & Robinson, 1964). The second and third, summarized collectively below, report on development of a training program and "rules of play" for infantry platoon leaders using a combined arms mapboard game (Shriver, Griffin, Hannaman, & Jones, 1979a and Shriver, Jones, Hannaman, & Griffin, 1979b).

In the first, a series of tactical exercises for use in tactical platoon training was developed. These were designed to teach essential tactical principles. In addition, the need for command and control was emphasized, and provision was made for the exercise of command decision and freedom of choice. In order to solve the problems of training costs and space, two miniaturized training "fields" were designed and fabricated. These were "The Miniature Armor Battlefield" and "The Armor Combat Decisions Game." (Baker, et al, 1964.)

Following training of tank platoon leaders and tank crews in the tactical exercises devised for the Miniature Armor Battlefield and of platoon leaders

on the Armor Combat Decisions Game, results of training were evaluated by means of an objectively scored field performance test and written Armor Combat Decisions Test. All of the groups who received experimental training made significantly higher scores on the field performance test and the written test than comparable groups not so trained.

The second and third reports (Shriver, et al, 1979a, 1979b) document and describe a simulation technique for training small unit leaders in tactical decision making. A two-sided, three-dimensional, free-play map board game was developed (a two-player game). A Controller is needed to give mission instructions (OPORDs) to the opposing force leaders (junior leaders, e.g., infantry or tank platoon leaders). The Controller role is crucial to the game as are the tables for Controller assessment of fire effectiveness, casualties, etc.

The map board game was developed to avoid the wasteful time spent by full-sized squads/platoons during the tactical training of platoon leaders. It is intended as an adjunct to SCOPES and REALTRAIN.

It was found that the junior leaders need to have the opportunity to learn to work with their NCOs. The map board game can be adapted for this purpose, that is, for platoon leaders to work with their squad leaders (a multi-player game). In addition, a small unit leader opposition exercise for use in the field was developed. This exercise requires only key leaders on each side. A combined arms mapboard game involving junior leaders was also developed.

The players get practice, in real time, in:

1. Anticipating enemy action.

2. Planning concerted action against the enemy.

3. Placing personnel in most advantageous positions against enemy.

4. Planning use of weapons based on effectiveness against enemy.

5. Command and control.

6. Contingency planning as more information is received.

In the critique following each game, the players learn that winning isn't necessarily the whole story. During this follow-up they are taught to recognize and assess the risks they have taken.

The US Army Command and General Staff College (C&GSC) at Fort Leavenworth, KS, has developed several computer based battle simulations which are used as procedural trainers for command and staff officers. The earlier larger unit -- main frame computer systems, such as Computer Assisted Map Maneuver Simulation (CAMMS) and Combined Arms Tactical Training System (CATTS), provided basic data and map overlay methods for the Army Training Battle Simulation System (ARTBASS), a more compact trailer-portable battalion trainer, and MACE*, a maneuver

*Not an acronym.

battalion/squadron procedures training system. MACE is microcomputer based and is capable of resolution down to one company, platoon, tank, or soldier. It offers practice and self-evaluation opportunities in tactical decision-making for the battalion level officers. It incorporates virtues of real time, flexibility, and free play, but a cost associated with these benefits is in human resources -- the large ratio of trainer-controllers to trainees, about 15 to 20. The C&GSC presently plans to field MACE to forty or more locations throughout the world in order to make its training benefits more readily available to combat units.

In addition, a study with potential implications for training (though not designed for that purpose) was found. As part of a project to develop standards for evaluating tank platoon battle run performance (Table IX), Allen, Johnson, Wheaton, Knerr, and Boycan (1981) asked two-man groups of experts to plan and execute an offensive and defensive mission using a terrain board and scale model tanks. After receiving an Operations Order, each participant initially worked independently in developing a plan, including route of travel, movement techniques, pre-planned fires, etc. Each plan was then presented to the other participant along with the rationale for various aspects of the plan. Using the Delphi method, each plan was discussed and the group then adopted one of the plans as it stood or consolidated the plans into a collective plan.

Implementation of the final plan was then carried out on the terrain board, with a Controller introducing various actions by the opposing forces. These actions necessitated modifications to the chosen plan as the mission progressed.

Consideration of tactical decision making, at least by Army personnel, would be incomplete without mentioning the Army's model for developing a tactical plan. A series of steps, described in the Army's Estimate of the Situation (DA FM 17-1, 1966), is prescribed at all levels of command for use in planning a tactical operation. During planning, the mission, enemy, terrain and weather, friendly troops, and time must be considered. The underlying processes involved include diagnostic assessments (for example, the disposition and weaponry of the enemy vs. one's own resources), generation of alternatives (for example, three alternate land routes for reaching an objective) and evaluation of the alternatives (for example, route A is considerably shorter than routes B and C but provides much less cover and concealment; route A leads to attacking the enemy on a flank, as does route B, but the flank at approach B has greater anti-tank strength, and so forth until the advantages and disadvantages of each route relative to the others have been considered and a route chosen).

A number of programs, some commercial (and primarily for civilian applications), seem to be meeting currently with some success. These appear to be described most inclusively and in greatest breadth in Hopf-Weichel, et al., (1979). Below, we have identified the programs by authors and organizations, and by the name of each program if one has been given. This is followed by the most salient characteristic found in the description and a summary of the Hopf-Weichel et al., appraisal of each program.

1. Einhorn and Hogarth. "An Idiot's Guide to Decision Making." For top level executives and middle level managers. Covers one method of alternative evaluation. Other tasks in decision making and their relationships are ignored.

2. Selvidge/Decisions and Designs, Inc. "Rapid Screening of Options." Requires an interactive computer program. Does not cover elements of decision making such as problem recognition and development of alternative courses of action.

3. Hammond, Stewart, Brehmer, and Steinman. Teaches the theory of judgment analysis in increasingly difficult applications. Does not treat other aspects of the decision making process.

4. Decision Analysis Group/Stanford Research Institute. This group provides several different training programs. Teaches that a decision theoretic methodology exists and that uncertainties and utilities can be quantitatively estimated. Programs have a reasonable degree of generality and completeness but fail to provide the required link between the training and specific application areas.

5. Elstein, Shulman, and Sprafka/Medical School of Michigan State University. For the training of physicians, integrates decision analysis into specific content areas based on the total curriculum. The program is task-specific and relies heavily on the case-study method.

6. Los Angeles Police Academy. "Shoot/Don't Shoot." (This descriptor has been so widely used that this is at least the unofficial name for this training program.) Provides extensive training in general guidelines that help cadets to make the decision. Cadets are taught to "prune the decision tree" before the actual situation arises. The program lacks the generality and completeness needed in decision making.

7. Kepner-Tregoe. (Apparently for the training of new managerial personnel.) Four main components of decision making are included: (1) situation appraisal, (2) problem analysis, (3) decision analysis, and (4) potential problem analysis. While little data exist to evaluate the process, Hopf-Weichel et al., acknowledge that the program has enjoyed continued commercial success. (The program was described by Kepner and Tregoe in 1965.)

8. Leal and Pearl/Perceptronics, Inc. Developed to facilitate group decision making through the use of an interactive computer system. While the decision aiding system was not designed to be a training device, Hopf-Weichel et al., report: "Through repeated sessions with the system, it is likely that decision groups will develop more efficient and focused techniques for problem definition and development of consensus" (p. 2-17).

The limitations of most people to weigh and combine more than one or two factors in arriving at a preference among alternatives suggests that these difficulties might be "trained around" rather than "trained out." Rather than teach decision making skills, this approach seeks to give the person an appropriate response or chain of responses to cope with an ambiguous situation.

Hopf-Weichel et al., (1979) describe one of the procedures used by the US Air Force in training aircrews to respond to emergency situations -- a procedure called BOLDFACE. The name derives from the large bold print in flight manuals which identifies critical emergency procedures. These are emergencies so critical that no time is available to refer to even a pocket checklist before action is taken; the appropriate procedures must be committed to memory during flight training.

To maintain the training, BOLDFACE procedures are reviewed thoroughly and frequently. Typically, written tests of all BOLDFACE procedures are taken once a month by all flight personnel. One of four BOLDFACE mini-tests is given once a week, and emergency questions of the day are posted on the flight schedule board for discussion by all personnel. In addition, BOLDFACE procedures are tested periodically in a simulator. Failure on any of the tests results in loss of flight privileges which can be regained only by reevaluation. The time period for reevaluation is up to the discretion of the command officer.

BOLDFACE has been criticized on several grounds. It does not take into account the overall task of the pilot in an emergency: maintaining aircraft control, analyzing the total situation, and planning ahead for a successful recovery. It ignores situational factors which might obviate the use of BOLDFACE procedures. Also, it treats emergencies arising from a single cause only, whereas aircraft mishaps often occur through a complex chain of events.

While BOLDFACE has limitations, its advantages are that the procedural requirements are unambiguous and easy to communicate and evaluate.

At a conference on aircrew emergency decision training held a few years ago, Edwards opened his remarks by recalling a technical report written in 1958 by Alex Williams on tactical decision making by fighter pilots. Edwards (1978) found the thesis of the report very simple and very persuasive, though (at the time he read it) "quite startling:" "It was simply that fighter pilots do not in fact make tactical decisions. If properly trained, they simply recognize pre-specified situations, whether of a routine or an emergency nature, and respond to them as they have been carefully trained to respond" (p. 14).

Edwards pointed out that the efficacy of this approach has since been borne out in the manned space flight program. A major goal of NASA has been never to lose an astronaut during a mission. To this end, extraordinary layers of redundancy have been built into the space systems and extremely elaborate contingency plans developed in the event of equipment failures and component malfunctions. Edwards, who was involved in the development of scenarios for use in training astronauts to meet emergencies in space, said that it had been extremely difficult for the simulation staff to construct any situation which required anyone (astronaut or controller) to make a decision.

The success of this approach is evidenced by the fact that no emergency ever occurred in a real flight that had not previously been included in one of the training simulation exercises.[1] Edward's point is that preplanning turns the problem of decision making into a problem of situation recognition. The trainee, then, must practice both the recognition and the pre-specified response to the situation. Situation recognition is like template matching -- a specific set of stimuli define a situation. If the stimuli match the template the pilot makes the response appropriate to it. Edwards conceded that a complete set of templates cannot be achieved. However, if the omissions are few in number and of low probability, there will be very few occasions in which a pilot will have to make a decision.

PROBLEMS REGARDING DECISION MAKING TRAINING

Developers of tactical decision making training programs are confronted with at least two major problems: (1) providing, in some measure, for consequences of decisions and (2) evaluating performance.

Consequences

The training program needs to capture the implications of real life effects of decisions, i.e., persons making simulated decisions must feel concern and responsibility for their decisions. Ideally, training programs should have the following characteristics:

1. Consequences of a decision should be perceived as important by and for the decision maker. Consequences of an incorrect decision should be perceived as important if not profound, involving implications with respect to the decision maker's career, physical or psychological self.

2. During training a decision should be clearly and directly related to its consequences and be perceived as leading directly to them. If factors outside the control of the decision maker can materially affect or change the consequences regardless of the decision made, or if the decision is relatively unimportant with respect to what finally happens, then consequences are not necessarily the result of the decision and the decision maker is not, and need not feel, responsible for them. (It is acknowledged, though, that in a real life situation the decision maker may be held responsible for them.)

This requirement, however, is contradictory to what we know about the outcome of decisions in combat situations. The outcome of very few, if any, decisions made by a platoon leader are completely within his control. (The problem of evaluation in decision making performance will deal with this point again.)

3. Consequences of a decision should be relatively immediate. If consequences are not immediate, the decision maker is less likely to feel responsibility for his actions. The more time intervening between a decision and its consequences the greater the opportunity for additional factors to affect or change the relationship between decision and consequences, justifying the decision maker's feelings of less responsibility.

[1] Based on a comment made to Edwards by the head of the simulation staff. The reference to this is dated 1968.

When these requirements, designed to insure that a decision maker will feel concern and responsibility for the consequences of his actions, are examined, the problem of the training developer is clear. Other than during actual combat, it will be extremely difficult to convey the decision consequences so that they are perceived as crucial by the decision maker for himself. (This is, of course, the problem of bringing motivation and stress into simulated training situations.)

Evaluation

Evaluating the quality of outcome is a key element to any training program. Yet, it is a weak point in decision training programs (Einhorn & Hogarth, 1981; Hopf-Weichel et al., 1979; Jensen, 1982; Nickerson & Feehrer, 1975). Nevertheless, without a sound evaluation plan there is no sure or defensible way to know if training has improved performance or not.

A set of objective criteria that is completely satisfactory and generally accepted has not yet been developed. No standard dependent variable has, or perhaps can be, found. The evaluator, lacking a single measure, is faced with other problems:

1. The quality of a decision is, among other things, dependent upon the information available. The information used by a tactical decision maker is usually incomplete, some of it fallible and some of it irrelevant. If the decision maker's performance is evaluated by the knowledge available to him it may be judged superior, yet its consequences could be far from desirable.

2. A tactical decision maker is not in control of the situation. Unexpected action on the part of the enemy and/or friendly troops, for example, can render a very good decision "bad" and conversely, a very bad decision "good."

3. Some situations may provide two or more equally good courses of action.

Nickerson and Feehrer (1975) discuss the importance of making a distinction between effectiveness and logical soundness of a decision. Effectiveness, which is usually easily determined after the fact, is simply the extent to which the result matches the outcome the decision maker had in mind. Logical soundness depends upon the consistency of the choice with the information available to the decision maker at the time of the decision. These authors strongly suggest that evaluation of decision making behavior be made in terms of logical soundness, not effectiveness. They note, however, that determining whether a decision has a logically sound basis, once it has been made, can prove very difficult, or at least that there may be some basis for skepticism. They remind us that there may be a natural propensity to convince outselves that our choices are determined by certain rational considerations, when in fact those considerations may be discovered or invented only after the choice is made.

Five factors for judging individual decision making behavior have been suggested by Sidorsky, et al., and by Hammell and Mara. (See Nickerson & Feehrer, 1975, p. 163.) These are: (1) The extent to which a decision maker responds in an unnecessarily predictable way; (2) The tendency of the decision maker to persist when persistence is unwarranted; (3) The extent to which the decision maker's behavior is reasonable in terms of time constraints of the situation; (4) The extent to which the decision maker uses all of the available, relevant information; (5) The consistency of the decision maker in responding within the context of a series of interrelated actions. Obviously, this set includes two liabilities and three assets.

TRAINING THE TANK PLATOON LEADER AS A TACTICAL DECISION MAKER

Bayes' Theorem

The use of Bayesian statistics to revise hypotheses or opinions of probabilistic events continues to receive strong support. In recognition of man's limitations in weighting and combining such information, the thrust of the more recent work is toward development of computer-based tactical decision aids. Among the early proponents of man-machine decision making systems was Edwards (1962). Nickerson and Feehrer (1975) and Samet (1978) have devoted considerable effort to describing the characteristics and capabilities that are essential to such systems. The work they report which is pertinent to computer-aided decision making has not been explored in any detail here since the use of computer-aided decision making systems was not considered feasible for the level of decision maker of primary concern in the present study. Nevertheless, it is our opinion that training in the use of Bayes' Theorem by an unaided tactical decision maker is not a realistic approach to improving decision making skills. Humans are not equipped, by sheer apperceptive mass, to make complex decisions by the application of Bayes' Theorem. The swift manipulation of decision-maker-defined values of variables known to be relevant, variables of ambiguous relevance, and new (heretofore unconsidered) variables in dynamic situations is simply not within the capability of the average person (Crecine, 1980, Edwards, 1962; Edwards et al, 1964; Samel, 1978; and Vaughan and Mavor, 1972).

BOLDFACE and The Estimate of the Situation

Of the programs reviewed, BOLDFACE and the Army's Estimate of the Situation model appear to offer the greatest promise.[1]

BOLDFACE. The BOLDFACE approach seems particularly suited for training and testing those decisions in tactical situations that must be virtually

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[1] Actually, "The Miniature Armor Battlefield" and "The Armor Combat Decisions Game" could be equally promising approaches. In personal communication with one of the staff members who participated in the development and tryout of these "games" it was learned that they were enthusiastically received by the trainees. However, the date of their development suggests that the then current tactics may be in need of considerable updating. Also, compared to the terrain board problem, these games require much more logistic support.

automatic (for example, reaction to enemy indirect fire). In many situations the significant decision is whether to initiate a new action or not (and as seen earlier, humans are slow to initiate an action or to alter an existing plan). When the decision is affirmative, the actions that follow are a fixed or prescribed chain of events which must be memorized. What is needed, then, is a set of stimuli to define a situation, time for the trainee to practice recognition of the situation and to rehearse, through verbal repetition, the appropriate chain of events.

Much as "emergency questions of the day" are posted for flight personnel in the BOLDFACE program, problems could be posted on a periodic basis for tank platoon leaders. The source for these might be critical incidents in which salient descriptors of situations are provided. The problem for the leaders would be to match the description with one of their learned "templates" and to identify the appropriate, i.e., pre-planned action(s) to be taken.

Written tests of all such procedures could be given on a periodic basis and augmented by requiring full performance of such procedures during battle drills.

In addition to pre-planning and rehearsal (such as BOLDFACE offers) the process of anticipatory decision making, or at least "pruning the decision tree" (such as the Los Angeles Police Department offers in its "Shoot-Don't Shoot" program) appear to be efficacious approaches to training in decision making when time is severely limited.

Estimate of the Situation. When time is not severely limited, e.g., in the planning of a mission, the Army's Estimate of The Situation is ". . . perhaps one of the most comprehensive models for ideal decision making" (Vaughan & Mavor, 1972, p. 269). The model, first published about 20 years ago, is periodically revised but the underlying process remains consistent and appears to encompass all of the eight activities listed earlier as a definition of decision making.

A variety of vehicles could be used to provide practice in applying the principles found in the Estimate Model. The terrain board problems described by Allen, et al., (1981) offer a good example.

Their offensive and defensive terrain board problems have been thoroughly analyzed and standards of acceptable performance, based upon the initial decisions of Army experts and a consensus procedure, are available. The terrain board, a scale model of actual terrain at Fort Knox, is still available.

Tape recordings of participants' defense or rationale for their original plan and for their subsequent decisions were made during the study. These recordings, if still available, could provide valuable insights into the relevant dimensions that influenced the decision process and could form the basis for critique of a trainee's performance. Because of the recency of this development, it is believed the terrain board problems could be readily converted into a training program.

These problems might be enriched by the addition of heuristics such as proposed by Bauer (1982). Based upon the debiasing procedures reported in Fischoff, et al., (1978) Bauer suggests that people can be trained to use base rate information rather than letting a singular presented datum outweigh basic probabilities. For example, "If the opposing force infantry is accompanied by tanks 80% of the time, but you see only light infantry, the opposing force infantry you see probably has tank support somewhere nearby."

While heuristics that are learned through formal training are highly resistant to change, descriptions of decision making processes by professionals demonstrate that they employ heuristics. Based upon their selection of a few items of information in an information-rich environment, they define the scenario or the situation they are in. The scenario is used to regenerate or reinterpret related information, and action results from this model. Theirs is a simplification process (based on past experience). In many time-constrained environments optimality may not be the real issue, simply survival and the chance to survive again (Crecine, 1980; Rigby, 1964).

To offset the resistance to changing a plan, once made, an observation made by Reitman (1964) (though in an entirely different context and not constrained by time) may be useful. In reviewing a protocol of a student composing a fugue he observed that some plans may coexist for a time -- that there are "connected alternatives." In making a plan, a tactical leader might employ this strategy by developing an overall plan but noting within this plan, where co-existing alternate actions might be taken depending upon the development of the situation at that time.

Providing practice on the terrain board problems combines both planning for the mission (not time-constrained) and making changes to the plan as the mission progresses (time constrained). For this reason some testing of BOLDFACE procedures might occur during the exercises. In addition, the process of anticipatory decision making could be practiced during the problems, though not directly tested; usage of these techniques might only be inferred by improvement in the timeliness of decisions.

A Taxonomy of Decision Making Tasks As the Basis for Training Development

One problem commonly encountered by developers of military training programs is that there are too many tasks to be trained within the training time available. A potential solution to this problem might be found, if a taxonomy of decision making tasks could be developed. The development of such a taxonomy is sketched out below:

1. Identify decision making tasks performed by tank platoon leaders.

2. Describe the skills and cognitive behaviors required of the decision maker for each task.

3. Classify the tasks according to these requirements.

The goal of the taxonomic development, of course, is to avoid the necessity of teaching decision making behaviors for every task that has been

identified. The taxonomy and the classifying characteristics common to each taxon would be used as the basis for development of a training program. Tasks selected for training might be chosen, based upon their representativeness or comprehensiveness of a given taxon. Of necessity, an integral part of the training program would be to provide a means of generalizing from the selected tasks to all tasks within a taxon.

As part of the development, once the taxa are identified it may be found that some classes of decision making tasks lend themselves to the development of algorithms that could be learned and applied in tactical situations. Other classes of decision making tasks might be more amenable to the development and use of heuristics.

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